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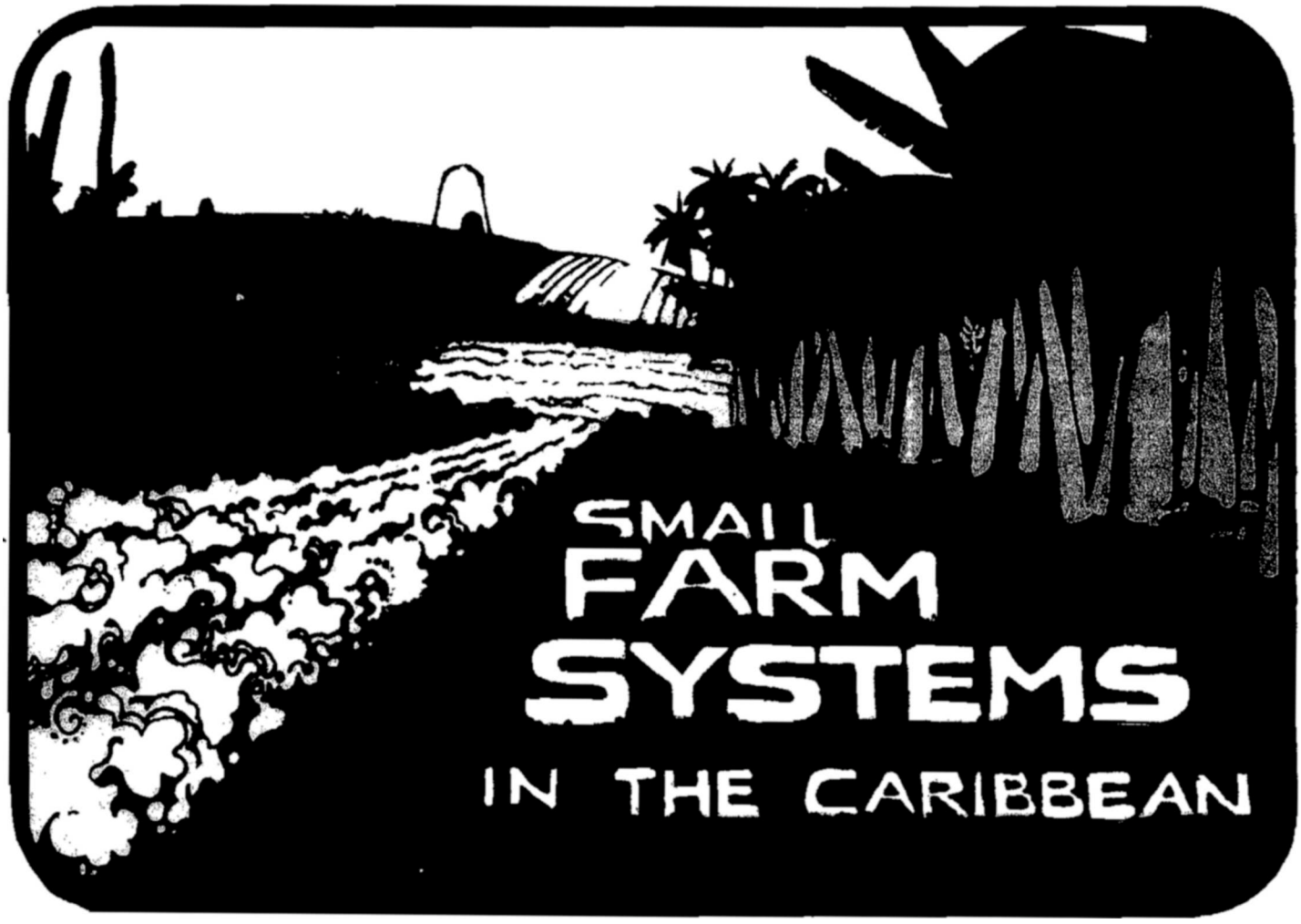

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Some Complements to Prakken's Theory for Pigmentation of Dry *Phaseolus Vulgaris* Beans

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Prakken's theory for seed colorations in dry *Phaseolus Vulgaris* beans is summarised. Some modifications are proposed in order to explain anomalies which appear in crosses between West Indian lines:

1. the possibility of new C alleles;
2. the existence among Haitian beans of a type of mottling which is not induced by C alleles;
3. the existence of a third allele, rki at the rk locus, besides RK and rk; and
4. the strong linkage between bright red, uniform or striped pod coloration, and the Crst gene.

Two practical applications are quoted as examples.

Very often it is not easy to make people accept new cultivars of food crops with shapes, sizes or colorations different from the traditional ones. In the West Indies, preferences are different in various islands for dry *Phaseolus vulgaris* beans. In the Dominican Republic people ask for large red mottled beans. The same type is asked for in Haiti, but with the influence of Cuban culture, black medium sized beans are also accepted. In Jamaica, people like red striped pink beans, and in the French West Indies, uniform red, large beans are preferred.

People who try to breed bean varieties for yield, adaptation to poor soils and disease resistance are therefore concerned by the coloration of their progenies, if they want their new cultivars to be accepted by consumers.

The Principal Genes Involved in Dry Bean Colorations, following Prakken's Theory

Not taking into account minor genes for dull or shiny beans, or for a yellow eye around the hilum, the principal genes involved in bean coloration according to Prakken (1979) are:

1. "P" which allows coloration (all the pp beans are white, whatever their other genes);
2. C, which allows full expression of the colors (the cc beans have pale colors); and
3. B (braun) G (geld), V (violett), inducing brown, yellow and purple pigments. The reunion of P,C,B,G, and V induces the dark coloration of black beans. These genes can explain the coloration of white, yellow, brown, buff, purple or black, uniformly colored beans. Striations and mottling, and also the special status of red beans remain to be explained.

Mottling may be induced by the heterozygous condition CC. This kind of mottling cannot be preserved in pure lines. It can also be induced by the stable Cm allele of C in pure inbred lines. But, in the same way as Cc heterozygotes, CmCm plants produce a minority (1 to 5%) of dark colored beans, the progeny of which is not different from that of mottled seeds.

This situation is still more conspicuous in striped beans, which possess the Cst allele of C and also produce a minority of dark beans.

The red coloration, which can appear only in lines homozygous for the recessive genes b,g and v, may be induced by a dominant gene R strongly linked with C. Such beans may be uniform red (CR), mottled red (CRm) or red striped (CRst). F_1 hybrids between CR and CRst produce red mottled beans, an unstable situation like for Cc.

Red coloration can be also induced by a recessive gene rk, which characterizes the "Dark Red Kidney."

Modifications or Complements to Prakken's Theory Necessary to Explain the Behaviour of Some Crosses Between West Indian Beans.

There are probably more alleles at the C locus than supposed by Prakken

When uniform colored black or red seeded interminate varieties of Haitian or South American origin ("Nicanor 2.4" from Haiti or "Maluquinho" from Brazil) are crossed with striped beans like "Miss Kelly" (Jamaica) or "Kenscoff I" (Haiti) F_1 plants do not produce mottled seeds, but rather dark ones (black or red) on which the naked eye can scarcely distinguish small light spots, like stars on a dark sky.

We can therefore suppose that these uniform black or red varieties possess a "stronger" C allele than the common "C" of the other varieties.

Among Haitian beans, we can also find pure lines in which this coloration is stable. For example, in "Azael 178 A," obtained from the Haitian breeder Ariel Azael, another allele probably exists at the C locus.

Some mottlings cannot be explained by the Cc or CmCm genotypes

Among Haitian lines there are some ("Nicanor 6.1," "Salagnac 120," "Kenscoff G") which are red or purple mottled, with large, dark, somewhat curved, irregular mottlings on a punctuated clear background. A minority of the beans produced by these lines are not darker, like for Cc or CmCm genotypes, but lighter, with only the small punctuations. When crossed with Cst striated lines, they give F_1 plants producing mottled beans. The F_2 plants show a very complicated segregation with not only the parental types, but also pale uniform colored beans, and others which show mottle and stripes together. This segregation has not been fully elucidated. It remains that there may be a kind of mottling which cannot be explained by the alleles of the C locus.

There are probably three alleles at the rk locus

Some West Indian lines, such as "Miss Kelly" (Jamaica) and "Kenscoff I" (Haiti) are striped on a pink background. This pink background behaves as recessive in crosses with CRm or CRst varieities with white or cream background (supposed to be Rk). In crosses with varieties which have had a coloration of the "Dark

Kidney" type (rk) the pink coloration behaves as dominant. We must therefores suppose thar there are rhree alleles ar the rk locus, with rhe following relarions of dominance:

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Rk	rki	rk
(cream or white background)	(pink background, i for "intermediate")	(red background)

But there is a curious complicarion: rhe lines which combine CRst and rK have dark purple stripes (which appear black) on a red background. For rhis darkening of stripes, rk appear, on the contrary, as dominant againsr rki. In crosses between "Red Caricosse" (a line wirh "Red Kidney" coloration, obrained by G. Anais and C. Vincent), and gR (a red striped pink, like "Kenscoff I" or "Miss Kelly"), we obtain a 6 - 3 - 3 - 3 - 1 segregation in F_2 plants. Six of them produce black striated pinks; three, red striared pinks; three, black striared reds; three, uniform pinks; and one produces uniform reds. But rhis situarion is actually caused by the strong linkage in "Dark Red Kidney" berween rhe recessive rk and a dominanr "stripe darkener" gene. We have obrained in later generarions a very low percenrage of recombinanrs (less than 1%) which are dark red srriped on a red background.

Interactions between Seed and Pod Colorations

Pod colorations in *Phaseolus vulgaris* beans could deserve the attention of a second Prakken! From a cross berween two European varieties, "Or du Rhin" (wax colored pods) × "Epicerie du Saulr" (brighr red colored pods, with chlorophyll at early stage), we have obrained dark purple pods in F_1 plants, and a very complex segregarion in rhe following generation, with wax, green, red, purple, bur also red wax and purple wax pods.

The curious observarion we have made in several crosses is that there is a tight linkage, (or perhaps a pleiorropy) berween the Crst gene for striped seeds, and the bright red coloration of the pods, either uniform or by srripes. For example, from a cross of "Scabiola Rossa" (red srriped pods) × "Dark Red Kidney" (green and later yellow pods), G. Anais and C. Vincent (INRA - Guadeloupe) have obrained either uniform color, or black srriped red seeded lines. The black striped seeded lines have brightly red srriped pods; on rhe conrrary, the uniform color seeded lines have only faint srripes on rheir pods.

CONCLUSION

As practical examples of rhe theorerical considerations exposed above, we can quote rhe following:

1. The reunion in new inbred lines of rhe CRm and rhe rki genes, which produce red mortled seeds wirh a pink background, a very pleasanr coloration. We have obrained by backcrosses rhe introduction of rhis new coloration into superior Haitian lines:
   a. "Kenscoff I" (extra early, powdery mildew tolerant, red srriared on a pink background).
   b. "Salagnac 86" (medium-early, powdery mildew and rust tolerant, lighr red mottled on white background).
   The coloration of rhese lines was nor dark red enough for Haitian consumers; their new versions with the Crm-rki combination will be better accepted.
2. The obrainment, for rhe French West Indies, of lines with beautiful red striped or uniform red pods, which enclose brighr red seeds, very arrractive for sale on the market for fresh shelled beans. The seeds may be black srriped red (the black stripes disappear ar cooking) or, still berrer, dark red srriped red.

References

1. Prakken, R 1979. Seed coat color in *Phaseolus Vulgaris*, attempt to a general synthesis. Annual Report Bean Improvement Cooperative 1979. pp. 74-78.